Volatility Transmission: What Does Asia-Pacific Markets Expect?

Shamiri, Ahmed
National University of Malaysia

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A.Shamiri
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
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ABSTRACT

The purpose of this paper is to investigate the international information transmission of return and volatility spillovers from the US and Japan and the rest of the Asia-Pacific markets using daily stock market return data covering the last 14 years. In the majority of the markets under scrutiny, we provide evidence of direct volatility spillovers, running mainly from the Japanese and US markets and pointing to more rapid information transmission during the recent years. First, the volatility of the Asia-Pacific markets is becoming influenced more by the US market for the recent years. Secondly, for international investors to get profits from the returns of Asia-Pacific securities, it is necessary to pay attention to the US market directly. Third, Korea, Singapore and Hong Kong are among the most Asia-Pacific markets vulnerable to shocks from US investors due to the large ratio of portfolio holding.

JEL classification: C32, G15

Keywords: Asia-Pacific; GARCH-BEKK; volatility spillovers; multivariate GARCH

1. Introduction

Nowadays, with the increasing liberalization and integration of global market activities, with the more growing integration of international financial markets, the study on the co-movement among international asset markets becomes more important. There is sufficient evidence that information is now shared more intensively across the world's major equity markets, and that markets have become increasingly integrated. The advantages of having integrated markets are well known: investors can share their consumption risk much more efficiently, which in turn decreases the costs of capital firms will face, hereby stimulating investment and economic growth. However, in the aftermath of the recent financial crises, many authors have argued that increased financial integration has intensified contagion effects across markets, causing severe welfare losses to large geographic regions. As a result, analysis of shock spillovers across countries and regions is important for many parties, including investors, risk managers, and regulatory and monetary authorities. The evidence from the crises of the 1990s suggests that crises are preceded by "excessive" capital inflows that, in turn, fuel large expansions in domestic credit and bubbles in financial markets (Sachs et al., 1996). There is also evidence that most episodes of banking crises are preceded by financial liberalization (Kaminsky and Sergio, 2002; Demirguc-Kunt and Detragiache, 1999). By the late 1980s, there was a revival of international lending. Capital inflows to Asia surged, with capital flows increasing tenfold from their averages in the early 1980s. This, however, changed the composition of capital flows, bank lending having been replaced by foreign direct investment (FDI) and portfolio investment. While FDI constituted the largest share of capital flow to Asia, portfolio investment (bonds and equity) also increased substantially, accounting for up to 40 % of total capital flows in the mid-1990s. In absolute terms, bond and equity flows to Asia (excluding those counted as FDI) increased to US$27 billion in 1993. As seen, booms in the 1990s were followed by capital flow reversals. The reversal occurred in the immediate aftermath of Thailand's currency crisis in December 1997, this reversal was

later aggravated by the Russian default in August 1998 and the Brazilian crisis in 1998-1999. The sudden stop in capital flows to Asia was more pronounced, with total capital flows declining from an inflow of US$120 billion in 1996 to an outflow of US$50 billion in 1998. The reversal of short-term portfolio flows to Asia (bonds, equities and bank lending) was equally as severe, with flows declining from an inflow of US$52 billion in 1996 to an outflow of US$92 billion in 1998. However, since year 2000 afterwards portfolio equity and FDI flows to the Asia have been on an uptick, but not necessarily to the same destination countries since the crisis. It is apparent that after reaching the lows in 1998, net portfolio equity flows bounced back in 2004, their highest levels since 1991. Although the international capital inflows to Asia are on the rise, there has been a fundamental shift in the nature of the region's engagement with the rest of the world. The Asian countries have consequently become a *net* exporter of capital to the rest of the world while still depending very heavily on *gross* financing from the rest of the world. Asian investors have systematically been transferring some balance sheet risks to the rest of the world by accumulating collateral in the form of relatively risk free assets in the US, as well as comparable Japanese assets.

Motivated by the large movements of capital flow to and out Asia-Pacific markets, our objectives are to analyze the fundamental forces driving volatility in Asia-Pacific stock markets. More specifically, we will focus on how and to what extent volatility in the individual Asia-Pacific equity markets is driven by shocks occurring in the US and Japan equity markets. This is not the first paper investigating volatility spillovers between equity markets. Ng (2000), suggest a greater influence from the US, whereas Miyakoshi (2003) study suggests a greater influence from the Japan on the Asia-Pacific markets. This contradictory of results is may be due the methodology used. However, all the previous studies were performed within one sample and without taking into consideration shifts of portfolio position in Asia-Pacific countries caused by the financial

crisis period, which will allow for a richer structure of the data. This paper, extend the methodology by taking into consideration of the crisis period, which allows examining the joint correlation and volatility dynamics shift between a high and a low state because of significant changes in the economics and financial environment. For example, a priori one would expect low volatility transformation from Japan or US to Asia-Pacific country if there is low capital inflow.

This paper considers a volatility spillover model by applying a bivariate BEKK-GARCH model of Engle and Kroner (1995), for which a BEKK representation is adopted, for each of the Asia-Pacific countries against the Japan and US using daily returns for the last-14 years. This BEKK formulation enables us to reveal the existence of any transmission of volatility from one market to another, as well as any increased persistence in market volatility (Engle et al., 1990). Splitting our sample into two non-overlapping sub-samples, we investigate whether the efforts for more economic, monetary and financial integration have fundamentally altered the sources and intensity of volatility spillovers to the individual stock market. The paper is organized as follows. Section 2 presents a bivariate BEKK-GARCH model between Japan and the US against each of the Asia-Pacific markets, while section 3 describes the data set and some financial stylised facts. Section 4 discusses the estimation results for individual markets and cross market analysis. Finally, section 5 draws the conclusion.

2. Methodology

The analysis is based on a bivariate VAR(1)-GARCH(1,1) model. Let R= ($R_{As,t}$, $R_{jp(us),t}$)′ be the return vector. The conditional mean of the process is modelled as follows:

$$\begin{pmatrix} R_{As,t} \\ R_{jp(us),t} \end{pmatrix} = \begin{pmatrix} c_{As,t} \\ c_{jp(us),t} \end{pmatrix} + \begin{pmatrix} A_{As,As} & A_{As,jp(us)} \\ A_{jp(us),As} & A_{jp(us),jp(us)} \end{pmatrix} \begin{pmatrix} R_{As,t-1} \\ R_{jp(us),t-1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{As,t} \\ \varepsilon_{jp(us),t} \end{pmatrix} \quad (1)$$

$$\varepsilon_t \mid \Im_{t-1} = \begin{pmatrix} \varepsilon_{As,t} \\ \varepsilon_{jp(us),t} \end{pmatrix} \sim N(0, H_t), \tag{2}$$

and

$$H_t = \begin{pmatrix} h_{AsAs,t} & h_{Asjp(us),t} \\ h_{jp(us)As,t} & h_{jp(us)\,jp(us),t} \end{pmatrix} \tag{3}$$

In the VAR(1) model above, $R_{As,t-1}$ represents the daily Asia-Pacific market returns and $R_{jp(us),t-1}$ are Japanese or US markets returns. The element $A_{As,\,jp(us)}$ is the degree of mean spillover effects from the Japanese or US markets to an Asia-Pacific market, or put differently, the current returns in Japan or US that can be used to predict future returns in an Asia-Pacific market. This multivariate structure then enables the measurement of the effects of the mean stock returns of one series on its own lagged returns and those of the lagged returns of other markets. We allow the error term ε_t to have a time-varying conditional variance that $\varepsilon_t \mid \Im_{t-1} \sim$ N (0, H_t). The $h_{AsAs,t}$ represents variance of an Asia-Pacific country, $h_{jp(us),t}$ is the variance of Japan or US and $h_{Asjp(us),t}$ represents the covariance between an Asia-Pacific country and Japan or US.

For the purposes of measuring of the Japanese and US market volatility on Asia-Pacific markets, the BEKK (Baba, Engle, Kraft and Kroner) model is employed, whereby the variance-covariance matrix of equations depends on the squares and cross products of ε_t and volatility H_t for each market lagged one period. One important feature of this specification is that it builds in sufficient generality, allowing the conditional variances and covariances of the stock markets to influence each other, and, at the same time, does not require the estimation of a large number of parameters (Karolyi, 1995). The model also ensures the condition of a positive semi-definite (PSD) conditional variance-covariance matrix in the optimisation process, and is a necessary condition

for the estimated variances to be zero or positive. The BEKK representation, introduced by Engle and Kroner (1995) is written as:

$$H_t = C_0' C_0 + \sum_{i=1}^{q} A_i' \varepsilon_{t-1} \varepsilon_{t-1}' A_i + \sum_{i=1}^{p} B_i' H_{t-1} B_i \tag{4}$$

where C_0, A_i and B_i are k × k parameter matrices with C_0 is a lower triangular matrix. Consider a bivariate GARCH (1,1) model as follows:

$$\begin{aligned} H_t = C_0' C_0 &+ \begin{bmatrix} \alpha_{As,As} & \alpha_{As,jp(us)} \\ \alpha_{jp(us),As} & \alpha_{jp(us),jp(us)} \end{bmatrix}' \begin{bmatrix} \varepsilon_{As,t-1}^2 & \varepsilon_{As,t-1}\varepsilon_{jp(us),t-1} \\ \varepsilon_{jp(us),t-1}\varepsilon_{As,t-1} & \varepsilon_{jp(us),t-1}^2 \end{bmatrix} \begin{bmatrix} \alpha_{As,As} & \alpha_{As,jp(us)} \\ \alpha_{jp(us),As} & \alpha_{jp(us),jp(us)} \end{bmatrix} \\ &+ \begin{bmatrix} \beta_{As,As} & \beta_{As,jp(us)} \\ \beta_{jp(us),As} & \beta_{jp(us),jp(us)} \end{bmatrix}' H_{t-1} \begin{bmatrix} \beta_{As,As} & \beta_{As,jp(us)} \\ \beta_{jp(us),As} & \beta_{jp(us),jp(us)} \end{bmatrix} \end{aligned} \tag{5}$$

where c_{ij} are elements of an $n \times n$ symmetric matrix of constants C, the elements α_{ij} of the symmetric $n \times n$ matrix A measure the degree of market shocks from market i to market j, and the elements β_{ij} of the symmetric $n \times n$ matrix B indicate the persistence in conditional volatility between market i and market j. For instant, $\beta_{As,jp(us)}$ represents the volatility spillover from Japan or US to an Asia-Pacific market. The model ensures that the conditional variance-covariance matrices, H_t are positive definite under weak assumption, that H_t is positive definite if at least one of C or B is of full rank. Engle and Kroner (1995) proved that the BEKK model is second-order stationary if and only if all the eigenvalues of (A⊗A + B⊗B) are less than unity in modulus. To elaborate further, the conditional variance for each equation can be expanded for the bivariate GARCH (1,1) as follows:

$$h_{As,t} = c_1 + \alpha^2_{As,As}\varepsilon^2_{As,t-1} + 2\alpha_{As,As}\alpha_{jp(us),As}\varepsilon_{As,t-1}\varepsilon_{jp(us),t-1} + \alpha^2_{jp(us),As}\varepsilon^2_{jp(us),t-1} + \beta^2_{As,As}h_{AsAs,t-1} + 2\beta_{As,As}\beta_{jp(us),As}h_{Asjp(us),t-1} + \beta^2_{jp(us),As}h_{jp(us)\,jp(us),t-1} \quad (6)$$

$$h_{jp(us),t} = c_3 + \alpha^2_{As,\,jp(us)}\varepsilon^2_{1,t-1} + 2\alpha_{As,\,jp(us)}\alpha_{jp(us),\,jp(us)}\varepsilon_{As,t-1}\varepsilon_{jp(us),t-1} + \alpha^2_{jp(us),\,jp(us)}\varepsilon^2_{jp(us),t-1} + \beta^2_{As,\,jp(us)}h_{AsAs,t-1} + 2\beta_{As,\,jp(us)}\beta_{jp(us),\,jp(us)}h_{Asjp(us),t-1} + \beta^2_{jp(us),\,jp(us)}h_{jp(us)\,jp(us),t-1} \quad (7)$$

To gain the statistical efficiency and better description on financial time series we account for the fat tails properties by adopting the leptokurtic multivariate distribution, such as multivariate Student-t density, the bivariate BEKK model is estimated by maximizing the following log-likelihood function:

$$L(\theta) = \sum_{t=1}^{T} \ln\, l((\theta)) \quad (8)$$

with $$l_t = \frac{\Gamma(T+v)/2}{\Gamma(v/2)[\pi(v-2)]^{T/2}}\left|H_t\right|^{-1/2}\left[1+\frac{1}{v-2}\varepsilon_t' H_t^{-1}\varepsilon_t\right]^{-(T+v)/2}$$

where υ denotes the degrees of freedom of the *t*-distribution and Γ is the gamma function. This log-likelihood function is maximized using the Berndt et al. (1974), which is also known as the BHHH algorithm.

3. Data and Hypotheses Testing

The stock markets investigated in this study are the US, Japan and the Asia-Pacific stock markets. The indices are Strait Times Index (Singapore), Hang Seng Index (Hong Kong), Korea Composite Stock Price Index, Taiwan Stock Exchange Capitalization Weighted, Kuala Lumpur Composite Index (Malaysia), Stock Exchange of Thailand Index, Jakarta Stock Exchange Composite Index (Indonesia), NIKKEI225 (Japan) and S&P500 (US). Daily index observations of these markets were obtained from DataStream data base. The indices span a period of

approximately 13 years from 1/1/1991 to 31/12/2004. In the database, the daily return R_t consisted of daily closing price P_t, which is measured in local currency.

Table 1 reports the descriptive statistics of stock returns for the samples under consideration, namely the pre-crisis and post-crisis. The mean returns in all Asia-Pacific markets are positive (with the exception of Korea for the first subsample and Taiwan for the second subsample) and six out of the seven Asia-Pacific markets have higher returns than the more developed markets in Japan and US for the more recent period. The Hong Kong and Malaysia markets yields the highest daily mean returns over the pre-crisis period, while Indonesia (0.059%) followed by Thailand (0.04%) has the highest mean returns for post-crisis period. The higher returns in the Asia-Pacific markets are, however, accompanied by higher volatility 1.52% and 1.63% for Indonesia and Thailand respectively. Notably, in terms of daily returns Japan have the lowest mean returns. It is clear that the Asia-Pacific markets offer higher average returns than Japan and US markets but these high returns are also characterized by higher volatility, which is common for emerging markets and is consistent with previous studies (Ng, 2000).

(Insert Table 1 here)

Moreover, we check the statistical features of the data reported in **Table 1**, the skewness, kurtosis, and their tests. The Ljung-Box Q-statistics Q(10) and $Q^2(10)$ are reported under the null hypothesis of non-serial correlation tests in daily return and squared returns, respectively. At significance levels of 5%, the null hypotheses (skewness=0 or excess kurtosis=0) and of non-serial correlation are rejected, respectively. These time series have the typical features of stock returns as fat tail, spiked peak, and persistence in variance. Therefore, the ARCH models including such features are appropriate for analyzing these series. Furthermore, these descriptive

statistics show that the nature of the data varies significantly between the two sub-samples, justifying our modelling strategy.

4. Empirical Results

Tables 2 and **3** report the estimation results of the US and Japanese spillover effects, for the both periods. The estimated coefficients shows that for both periods and in all case,

$$| R_{As\,jp} | < | R_{As\,us} |$$

With all significant R_{us} and all non-significant R_{jp} except for Taiwan during post-crisis, indicating that the Asia-Pacific markets return are influenced only by the world factor of the US market. This suggests that the US mean returns, on average, improved market sentiments in the Asia-Pacific leading to upward adjustments of earnings forecasts for the markets since the Asia-Pacific return increase when the US return increases. In the other hand, the Japanese mean return spillover effects as reported in **Table 2 and 3**, shows there is no immediately discernable pattern of response to overall mean spillover across the markets as shown by non-significant coefficients (exception, Taiwan during the post-crisis period with statistically significant estimated coefficient of 0.056). The reason for Japan to have a significant effect on Taiwan's market during the post crisis could be due the sudden increase of Japanese portfolio holding of Taiwan's securities from 307 million to 813 million (165% increase). The results of mean spillover are found to be similar to Ng (2000) and Miyakoshi (2003). The significant of the mean spillover from the US can be attributed to the time difference of opening and closing hours between the Asia-Pacific markets and US, while there are overlaps between trading hours of Japan and Asia-Pacific markets, the US market is closed when non-US markets are opening. The information flow from the Japanese market, which can be regarded as regional information, is thus contemporaneous while US

market news, which constitutes global information, can influence the Asia-Pacific markets when they open 3-4 hours after the US market close.

However, Asia-Pacific market volatility is in general more influenced by the Japanese market than by the US during the pre-crisis period $|\beta_{As\ jp,}| > |\beta_{As\ us}|$. A different picture is drawn for the post-crisis period, the US market volatility has in general more effects on Asia-Pacific $|\beta_{As\ us}| > |\beta_{As\ jp}|$. These results support Ng (2000) for the period of post-crisis, while the results for pre-crisis are in line with Miyakoshi (2003). The conflict of both authors (Ng, 2000) and (Miyakoshi, 2003) in terms of volatility spillover could be due the sample span and, not taking into consideration the crisis effect, which has caused portfolio investment to change it portion of Japanese and US investors holding Asia-Pacific securities.

(Insert Table 2 here)

Starting with Korea, Singapore and Hong Kong, we find that volatility in these countries is significantly affected by the US and Japanese volatility ($\beta_{As\ us}$, $\beta_{As\ jp}$) during the post-crisis periods under examination . In this sense, more intense volatility spillovers are expected during the post-1997 period and milder ones during the pre-1997 one, mainly due to the persistence of the US volatility. However, US influences are stronger than the Japanese influences. Hong Kong market is not affected by the US market volatility during the pre-crises, while there is volatility transformation from the US market to Hong Kong market for the pre-crises. This is surprising, one would expect the Hong Kong and US economies to be closely linked. The Taiwan's market is not influenced by US nor Japan during the pre-crisis, this finding suggests that volatility in Taiwan may be driven heavily by local shocks or other shocks unrelated to the US and Japan markets, such as political risk and shocks from china. In the case of Malaysia, there is significant volatility spillovers from the Japanese markets transmitted through the volatility coefficient. During the pre-crisis the effects of Japan markets on the Malaysian volatility is shown to be more

intense with a significant coefficient from Japan -0.0127 (p = 0.0000) than the volatility during post-crisis US -0.0488(p = 0.0382). Thailand, the volatility is transmitted through the Japanese volatility for the first period, while through the US market volatility for the second period. No volatility is transmitted to Indonesia market from both US and Japan; however it is transmitted through both the Japanese and US markets volatility during the second sub-sample. However, our estimates for the pre-crisis period support the increased integration of Japanese markets with the Asia-Pacific markets, due a strong economic relationship through a large amount of portfolio investment between Japan and Asia-Pacific countries. However, the integration of Japanese markets with the Asia-Pacific market had been reduced in the recent years due to the increase of capital flow from US to Asia-Pacific countries as well as capital outflow from Asia-Pacific countries and Japan to US market, searching for more stable economic.

Though the Asia-Pacific market volatility is influenced in general by the US market for the more recent period and the Japanese Volatility in the past, their own effects of the previous day on the present day remain larger than the US and Japan volatility.

(Insert Table 3 here)

Finally, the Ljung-Box Q statistics in **Table 4** show no evidence of autocorrelation in the standardised residuals (all of the p-values are greater than .05) Given that conditional expected return equations provide an adequate description of the data, we can conclude that the conditional mean return equations are correctly specified.

(Insert Table 4 here)

The paper gives an economic justification about the results on volatility between US, Japan and Asia-Pacific countries. As seen in **Table 5**, **6** and **Figure 1** that, it only focuses on equity securities, since this data will directly affect the stock market returns and volatility. **Figure 1**

shows how much the Japanese and US investors came to hold the Asia-Pacific securities during the periods of examination. A noticeable increase of the portfolio invested in Asia-Pacific countries by US investors during and after the Asian financial crisis.

(Insert Figure 1 here)

The ratios A/AJP (A/AUS) and A/AS in Panel A of **Table 5** and **6**, denote the ratio of each Asia-Pacific stock (A) held by Japanese or US investors to the average market capitalization of (AJP) the Japanese stock market, the average market capitalization of (AUS) the US market and the average market capitalization of (AS) of each Asia-Pacific country's stock market, respectively. Panel A shows the behaviour of Japanese and US investor as well as the shifts in portfolio investment holdings. **Table 5** Panel **A**, indicates that the Japanese investor has decreased their portfolio holdings of Asia-Pacific securities during the post-crisis compared to pre-crisis periods. On the contrary, US investor has increased their holding of Asia-Pacific securities during the more recent period. This clearly explains the volatility spillover from US to Asia-Pacific markets during the more recent years (as shown by $\beta_{As\ us}$). US investors hold 18.77%, 13.97%, and 5.39% of the total market capitalization of Korea, Singapore and Hong Kong stock market respectively. Similarly, the B/AS in Panel B of **Table 6** indicates that US stocks (B) held by each Asia-Pacific investor display 38.89%, 2.91% of total market capitalization (AS) of Singapore and Hong Kong. These large ratios suggest that the Korea, Singapore and Hong Kong markets will be rocked by such crisis happing in US markets through the US investors holding the Asia-Pacific stocks. These countries become a symbol of expanding business overseas for both US and Japanese investors. Finally, the result for Malaysia provides an exception worthy of note, that it has the least of the US and Japanese investors holding. This is easily explained the Malaysian capital control.

(Insert Table 5 here)

(Insert Table 6 here)

5. Concluding remarks

This paper investigates the dynamic interaction and changing nature of the return and volatility spillovers from Japan and the US to the Asia-Pacific markets. Price and volatility spillovers are examined in the context of a multivariate Generalized Autoregressive Conditional Heteroskedastic (GARCH), by adopting a bivariate BEKK representation and splitting our sample into sub-periods. Unlike previous related studies, this paper fully takes into account the crisis period and portfolio investment position.

The major empirical findings are fourfold. First, only the influence of the US market is important on the Asia-Pacific markets mean returns; there is no influence from Japan market for both periods on the Asia-Pacific markets (except for Taiwan for the post-crisis period). Secondly, Korea, Singapore and Hong Kong are more prone to changes in US economy as US investors hold 18.77%, 13.97% and 5.39% of Asia-Pacific total market capitalisation, respectively. In addition, Singapore and Hong Kong holds 38.89% and 2.91% respectively of US assets to the total of their market capitalisation. Such large ratios will increase their risk exposure to US financial markets. Thirdly, significant volatility spillovers from the Japanese and US markets to Asia-Pacific markets. Asia-Pacific markets volatility is influenced more by the Japanese market than by the US market for the pre-crisis period. However, this is not true for the more recent period, as capital flows from US to Asia-Pacific markets has made the US the main source of international volatility to the region. Nonetheless, it is informative to note that the flows into US market have surged following the Asian crisis as regional central banks and investors have rapidly built up their reserves. The increased demand for US corporate bonds from Asia-Pacific and elsewhere has been pushed by the relative scarcity of high-grade debt issuances, while also being pulled specifically into the US due to the deep and highly liquid nature of US capital markets. In other words, the US in the main but also Japan has served as international financial intermediaries to Asia.

A pre-and-post crisis analysis reveals that the Asia-Pacific markets have become more sensitive to volatilities originating from US and Japan. In contrast to Ng (2000) and Miyakoshi (2003) studies which represents the primary previous research in this field, the results of this study suggest a greater influence from the Japan on Asia-Pacific volatility than from the US for the pre-crisis period and find an increase influence from US to Asia-Pacific for the more recent years, as capital inflow from US to Asia-Pacific increase. The differences between our results and the previous studies stem from a strong economic relationship between US and Asia-Pacific countries through the large amount of portfolio investment during the year 2000 and afterwards. The previous studies did not take into account the crisis period neither showed shifts of portfolio investments. Thus, our paper purely examines the volatility spillover effects of the Japanese and US market within two sub-periods.

Our finding suggests that for international investors to get profits from the returns of Asia-Pacific securities, it is necessary to pay attention to the US market directly. However, Asia-Pacific volatility is influenced as well by Japanese market volatility. Implementing global hedging strategies and asset allocation decisions on Asia-Pacific markets requires the information concerning the Japanese volatility behaviour.

References

Connolly, R.A., Wang, F.A., 2003, On stock market return co-movements: Macroeconomic news, dispersion of beliefs, and contagion. Pacific-Basin Finance Journal 11(1), 23-43.

Demirguc-Kunt, A., Detragiache, E., 1999, Financial Liberalization and Financial Fragility. In Annual World Bank Conference on Development Economics, World Bank, Washington DC 303-31.

Engle, R.F., Kroner, K.F., 1995, Multivariate Simultaneous Generalized ARCH. Econometric Theory 11 (1), 122–150.

Kaminsky, G., Sergio, S., 2002, Short-Run Pain, Long-Run Gain: The Effects of Financial Liberalization. World Bank Working Paper, Washington, DC.

Karolyi, G.A., 1995, A multivariate GARCH model of international transmissions of stock returns and volatility: the case of the United States and Canada. Journal of Business & Economic Statistics 13 (1), 11–25.

Kim, S.J., 2003, The spillover effects of US and Japanese public information news in advanced Asia-Pacific stock markets. Pacific-Basin Finance Journal 11, 611-630.

Kim, S.W., Rogers J.H., 1995, International stock price spillovers and market liberalization: Evidence from Korea, Japan, and the United States. Journal of Empirical Finance 2, 117-133.

Miyakoshi, T., 2003, Spillovers of stock return volatility to Asian equity markets from Japan and US. Journal of International Financial Markets, Institutions & Money 13, 383-399.

Ng, A., 2000, Volatility spillover effects from Japan and the US to the Pacific-Basin. Journal of International Money and Finance 19, 207–233.

Sachs, J., Tornell, A., Velasco, A., 1996, The Collapse of the Mexican Peso, What Have We Learned? Brookings Papers on Economic Activity.

Wei, K.C.J., Liu, Y.J., Yang, C.C., Chaung, G.S., 1995, Volatility and price change spillover effects across the developed and emerging markets. Pacific-Basin Finance Journal 3, 113–136.

Table 1. Summary statistics for daily equity market returns

	Singapore	Hong Kong	Malaysia	Indonesia	Thailand	Korea	Taiwan	Japan	US
Panel A: Pre-crisis									
Mean	0.048	0.095	0.058	0.027	0.021	-0.004	0.027	-0.011	0.052
Std.	0.941	1.365	1.129	0.907	1.478	1.328	1.738	1.076	0.655
Skewness	-0.162**	-0.529**	0.130**	0.360**	-0.082*	0.361**	-0.042*	0.352**	-0.094*
Kurtosis	8.196**	7.706*	10.924**	11.793**	8.173**	5.607*	6.227**	8.299**	5.688*
Q(10)	67.34	40.89	82.03**	297.75**	42.64	32.33	43.30	70.79**	47.13*
$Q^2(10)$	214.72**	376.77**	695.91**	252.53**	391.80**	488.37**	704.38**	332.69**	103.30**
ARCH(5)	120.66**	112.73**	226.58**	164.55**	173.55**	219.87**	159.78**	129.49**	24.10**
Panel B: Post-crisis									
Mean	0.025	0.022	0.028	0.059	0.040	0.030	-0.003	0.001	-0.001
Std.	1.275	1.460	1.140	1.524	1.626	2.106	1.751	1.356	1.229
Skewness	-0.327	-0.234	-0.144	0.004	0.245	-0.355	-0.012	-0.304	0.112
Kurtosis	6.973	5.871	7.884	8.115	6.407	5.514	5.160	5.047	4.764
Q(10)	44.90	26.03	91.94**	62.66**	56.77**	35.41	49.75*	65.17**	43.39
$Q^2(10)$	149.21**	195.74**	371.77**	115.97**	158.16**	122.73**	349.24**	190.53**	654.22**
ARCH(5)	37.54**	18.17**	138.87**	49.47**	67.21**	38.76**	73.92**	79.21**	134.90**

Standard errors are given in parentheses. **,* Significant at 1% and 5% respectively.

Table 2. Spillover effects from the BEKK model for the pre-crisis period

	Singapore	Hong Kong	Malaysia	Indonesia	Thailand	Korea	Taiwan
			Mean Equitation				
$R_{As\ us}$	0.1985**	0.1455**	0.1088**	0.1010**	0.0745**	0.0207	0.0382**
	(0.0134)	(0.0088)	(0.0119)	(0.0153)	(0.0087)	(0.0111)	(0.0091)
$R_{As\ jp}$	0.0015	-0.0156	-0.0127	-0.0013	0.0133	0.0341	0.0118
	(0.0258)	(0.0177)	(0.0221)	(0.0245)	(0.0141)	(0.0172)	(0.0116)
			Variance Equitation				
Own effects							
$\beta_{As\ As}$	0.8416**	0.8989**	0.9076**	0.8089**	0.8027**	0.9056**	0.9298**
	(0.0212)	(0.0101)	(0.0095)	(0.0150)	(0.0249)	(0.0166)	(0.0085)
US effects							
$\beta_{As\ us}$	-0.0264*	-0.0116	0.0139	0.0241	-0.0413	-0.0107**	0.0355
	(0.0111)	(0.0198)	(0.0140)	(0.0215)	(0.0364)	(0.0039)	(0.0235)
Japan effects							
$\beta_{As\ jp}$	-0.0906**	-0.0238**	-0.0127**	-0.0016	-0.0217*	-0.0281**	-0.0034
	(0.0145)	(0.0046)	(0.0085)	(0.0238)	(0.0100)	(0.0097)	(0.0151)

Standard errors are given in parentheses. **,* Significant at 1% and 5% respectively.

Table 3. Spillover effects from the BEKK model for the post-crisis period

	Singapore	Hong Kong	Malaysia	Indonesia	Thailand	Korea	Taiwan
			Mean Equitation				
$R_{As\ us}$	0.3244**	0.3445**	0.2239**	0.1237**	0.1227**	0.1842**	0.1479**
	(0.0193)	(0.0154)	(0.0228)	(0.0154)	(0.0152)	(0.0115)	(0.0148)
$R_{As\ jp}$	-0.0272	-0.0212	0.0345	-0.0180	-0.0134	0.0162	0.0562**
	(0.0284)	(0.0235)	(0.0259)	(0.0209)	(0.0197)	(0.0166)	(0.0185)
			Variance Equitation				
Own effects							
$\beta_{As\ As}$	0.9338**	0.9826**	0.9262**	0.8868**	0.8860**	0.9716**	0.9597**
	(0.0108)	(0.0034)	(0.0074)	(0.0118)	(0.0135)	(0.0041)	(0.0071)
US effects							
$\beta_{As\ us}$	-0.0274**	-0.0210*	-0.0074	-0.0197*	-0.0200*	-0.0634**	-0.0441*
	(0.0082)	(0.0094)	(0.0057)	(0.0088)	(0.0110)	(0.0130)	(0.0090)
Japan effects							
$\beta_{As\ jp}$	-0.0369**	0.0006	-0.0488*	-0.0248*	-0.0221	-0.0619**	0.0273*
	(0.0128)	(0.0112)	(0.0113)	(0.0126)	(0.0151)	(0.0148)	(0.0119)

Standard errors are given in parentheses. **,* Significant at 1% and 5% respectively.

Table 4. Test for standardized residuals

	Singapore	Hong Kong	Malaysia	Indonesia	Thailand	Korea	Taiwan	Japan	US
Panel A: Pre-crisis									
L-B Statistics	11.68	4.416	13.04	6.567	9.934	7.898	13.23	5.881	14.45
p-value	0.4716	0.9747	0.3665	0.8849	0.6217	0.7930	0.3525	0.9220	0.2728
Panel B: Post-crisis									
L-B Statistics	5.789	6.459	6.48	1.509	17.70	8.115	17.16	3.90	12.20
p-value	0.9263	0.8912	0.8900	0.9999	0.12496	0.7761	0.1436	0.9852	0.4301

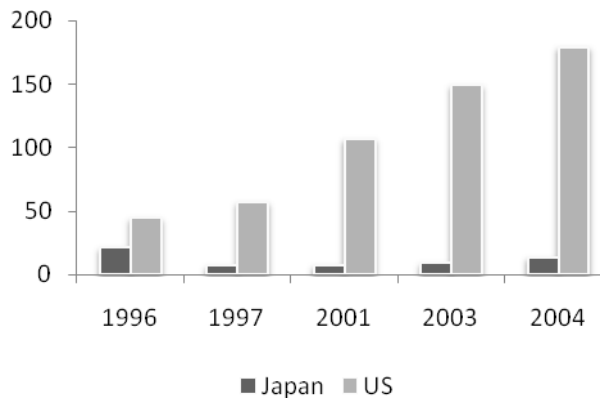

Figure 1: US and Japan holding of Asia-Pacific securities

Table 5. The portfolio investment position between Asia-Pacific countries and Japan at yearend

Year	Singapore	Hong Kong	Malaysia	Indonesia	Thailand	Korea	Taiwan
Panel A: Japanese Portfolio Holdings of Asia-Pacific Securities ($US mil)							
1996	2920	11229	4532	578	1291	125	307
1997	1184	4091	1066	168	221	70	209
1998	771	4177	459	108	381	139	246
1999	2123	7296	390	161	680	656	561
2000	1560	4754	278	74	365	292	412
2001	929	4875	340	50	291	383	397
2002	914	3210	295	121	241	538	269
2003	1279	5591	296	89	393	708	591
2004	1718	9232	184	115	276	958	813
Pre-crisis							
A/AJP	0.08%	0.29%	0.11%	0.01%	0.03%	0.00%	0.01%
A/AS	1.58%	1.78%	1.40%	0.62%	1.27%	0.11%	0.09%
Post-crisis							
A/AJP	0.04%	0.15%	0.01%	0.00%	0.01%	0.02%	0.01%
A/AS	0.88%	0.93%	0.21%	0.22%	0.56%	0.23%	0.15%
Panel B: Asia-Pacific Portfolio Holdings of Japanese Securities ($US mil)							
1996	7876	8303	0	3	0	52	204
1997	4950	5697	1	2	0	0	132
1998	4434	3832	0	0	0	0	72
1999	4402	10941	9	2	4	6	1559
2000	11149	11753	3	1	4	166	929
2001	9002	6677	15	2	4	231	1471
2002	2218	4585	8	2	6	203	553
2003	3068	6889	21	2	10	370	467
2004	3415	9204	14	2	21	470	608
Pre-crisis							
B/AJP	0.24%	0.26%	0.00%	0.00%	0.00%	0.00%	0.01%
B/AS	4.94%	1.62%	0.00%	0.00%	0.00%	0.03%	0.06%
Post-crisis							
B/AJP	0.15%	0.22%	0.00%	0.00%	0.00%	0.01%	0.02%
B/AS	3.45%	1.32%	0.01%	0.00%	0.01%	0.09%	0.28%

- Source: Bank of Japan.
- A, B denotes the average portfolio holding.
- AJP, AS denotes the average of total market capitalisation of Japanese and Asia-Pacific markets.
- Data displayed in $US using yearend exchange rate.

Table 6. The portfolio investment position between Asia-Pacific countries and US at yearend

Year	Singapore	Hong Kong	Malaysia	Indonesia	Thailand	Korea	Taiwan
Panel A: US Portfolio Holdings of Asia-Pacific Securities ($US mil)							
1994	6832	17527	9115	1935	4113	4352	468
1997	10185	28102	4713	2488	2158	4428	4939
2001	21376	30154	2578	1526	1916	29537	19607
2003	21932	36210	4075	4406	6477	49121	26970
2004	23968	35395	6474	6116	5961	66639	34554
Pre-crisis							
A/AUS	0.09%	0.24%	0.07%	0.02%	0.03%	0.05%	0.03%
A/AS	6.56%	5.29%	3.46%	3.69%	5.28%	4.85%	0.95%
Post-crisis							
A/AUS	0.16%	0.25%	0.03%	0.03%	0.03%	0.35%	0.20%
A/AS	13.97%	5.39%	3.13%	8.86%	7.14%	18.77%	8.12%
Panel B: Asia-Pacific Portfolio Holdings of US Securities ($US mil)							
1994	8134	5894	133	148	131	152	1031
1997	37341	18312	510	519	427	580	6585
2001	44786	15329	372	401	224	483	4748
2003	69046	17087	340	317	185	549	5067
2004	73536	22499	1269	322	310	941	7866
Pre-crisis							
A/AUS	0.09%	0.06%	0.00%	0.00%	0.00%	0.00%	0.01%
A/AS	6.27%	1.37%	0.07%	0.25%	0.22%	0.17%	0.36%
Post-crisis							
A/AUS	0.45%	0.13%	0.00%	0.00%	0.00%	0.00%	0.04%
A/AS	38.89%	2.91%	0.47%	0.77%	0.36%	0.25%	1.77%

- Source: US Department of Treasury.
- A, B denotes the average portfolio holding.
- AUS, AS denotes the average of total market capitalisation of US and Asia-Pacific markets.